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AN APPRAISAL OF GREEK SCIENCE

Despite the increased attention that has been given, in comparatively recent years, to the history of science and to the history of Greek science in particular,[1] the opinion is still prevalent in many quarters that the scientific aspect of the Greek genius is only of secondary importance. In the Hellenic period, it is held, patient and detailed observation and explanation of phenomena were neglected for philosophical and metaphysical speculation as to the ultimate constitution of matter and of the universe; while in the Hellenistic and subsequent periods, when more attention was devoted to the special sciences, organized experiment, it is held, was rarely undertaken and, in any case, very little progress was made toward the discovery of those quantitative relations with which modern experimental science so largely concerns itself. There is, of course, an element of truth in these views, and certainly they have not been confined to superficial thinkers. Thus Alfred Whitehead writes (Science and the Modern World, 10):

> The Greek genius was philosophical, lucid and logical. . . . Their minds were infected with an eager generality. They demanded clear, bold ideas, and strict reasoning from them. All this was excellent; it was genius; it was ideal preparatory work. But it was not science as we understand it. The patience of minute observation was not nearly so prominent. Their genius was not so apt for the state of imaginative muddled suspense which precedes successful inductive generalization.

And George Santayana (Reason in Science, 4-5):[2]

> The first period in the life of science <i. e. the Greek period> was brilliant but ineffectual. . . . Men of science were mere philosophers. . . . No scientific tradition could arise, and no laborious applications could be made to test the value of rival notions. . . . Another circumstance that impeded the growth of science was the forensic and rhetorical turn proper to Greek intelligence. . . . Worse influences in this field could hardly be imagined, since Plato's physics ends in myth and apologue, while Aristotle's ends in nomenclature and teleology.
>
> All that remained of Greek physics, therefore, was the conception of what physics should be—a great achievement due to the earlier thinkers—and certain hints and guesses in that field. . . .
>
> At its second birth <i. e. the Renaissance period> science took a very different form. . . . It was a patient siege laid to the truth which was approached blindly and without a general, as by an army of ants; it was not stormed imaginatively as by the ancient Ionians, who had reached at once the notion of nature's dynamic unity, but had neglected to take possession, in detail, of the intervening tracts, whence resources might be drawn in order to maintain the main position.

The danger in views such as those I have just quoted lies in the emphasis placed upon only one aspect of the scientific activity of the Greeks, i.e. the consideration of those larger questions where science and philosophy merge. I shall try in what follows to show that, although of the greatest importance, this is a very incomplete view of the science of the Greeks and should not be made the sole basis of a comparison between Greek scientific thought and the scientific thought of subsequent ages. An embracing view of the subject would include the whole development of approximately a thousand years, and would be concerned not only with the working of the mind of the Greek scientist-philosopher grappling with the basic questions of existence and reality, of the infinite and the infinitesimal, of continuity and discontinuity, of determinism and chance, of change and persistence, of space and time, of substance and form, but would consider also the working of the mind of the Greek scientist seeking to find order in the motion of

[1] Complete bibliographical material may be found in: George Sarton, An Introduction to the History of Science, Volume I (The Carnegie Institution of Washington, 1927), supplemented by the Critical Bibliographies regularly appearing in Isis; P. Brunet and A. Mieli, Histoire des Sciences: Antiquité (Paris, Payot, 1935).

[2] See also Henry O. Taylor, Greek Biology and Medicine, 42 (Boston, Marshall Jones Company, 1922).

heavenly bodies, or to discover the size and shape of the earth, or the distance of sun, moon, and stars, or to understand the phenomena of lever, pulleys, vibrating strings, floating bodies, falling bodies, projected bodies, reflected and refracted light, rainbows, eclipses, and a thousand others. An embracing analysis would concern itself not only with the work of the Greek physician observing and recording the course of disease, or studying, by dissection, the functions of organs and tissues, or classifying the known species of plant and animal life, or investigating the homology of organs in various species, but also with the working of the mind of the humblest artisan as he faces the problems constantly posed by his craft and from the solution of which the application of the rational method of science may be inferred. In the nature of the case I shall not be concerned so much with a precise cataloguing of substantive achievements as with methods of attacking and answering problems and with the progress of the spirit of rational investigation.

Before we examine the work of the Greeks in the physical and experimental sciences, work which is not, as we have seen, the object of widespread appreciation, let us consider briefly a field in which the greatness of Greece is universally acknowledged, pure mathematics. But precisely in what does the greatness consist? The growth of our knowledge and appreciation of Egyptian and of Babylonian mathematics[3] so far from dimming the brilliance of Greek mathematical achievement has given it new luster. In Egypt at least a thousand years before the dawn of Greek mathematics, problems that were by no means confined to the 'practical' were posed and solved, the constancy of the ratio of the circumference to the diameter of the circle was accepted and a remarkably close approximation to its value employed, formulas stating exactly or with close approximation the areas or volumes of various geometrical figures were known; and even before this, among the Babylonians, remarkable skill had been attained in the solution of arithmetical and geometric problems leading to linear, quadratic, and cubic equations. But, so far as we know, the ideal of the rigorously deductive proof still remains the achievement of Greek mathematics. The Egyptian mathematician checked his work in the sense that he showed the solution fulfilled the terms of the problem; the Greek mathematician has, by the fourth century or earlier, attained complete control over the method of proof by axioms, postulates and a series of theorems. The Egyptian mathematician is adept at certain types of fractions, and, with their help, solves problems in arithmetic and geometric progression; the Greek mathematician goes further and works out a deductive theory of ratio and proportion which by its application to incommensurable quantities serves to clarify the problem of the irrational, and influences all subsequent thought on the subject of mathematical continuity. The Babylonian mathematician achieves brilliant results after what is, presumably, an empirical discovery of correct methods; but the sense of the logically demonstrable character of correct procedure still must be placed to the credit of Greece. Not that the Greeks were unappreciative of the importance of empiricism in the *discovery* of certain types of theorems, as distinguished from their *proof*. Archimedes does not hesitate to apply the principle of the lever to aid the discovery of mathematical relations of areas or volumes, a procedure described in The Method. But the complete distinction between this procedure and deductive proof is never forgotten by the Greek mathematician. Though the debt of Greek mathematics to Egypt and the East was great, the advance beyond them was far and decisive.

In passing from pure mathematics to the substantive sciences, let us recall very briefly something of the aims and methods of the various types of science. Science seeks to find elements of order in the phenomena of nature—order in the sense of some invariant relation. This invariant relation may take the form of an invariable association of properties which permits us to recognize and to classify a particular body or a particular animal as this or that substance or as this or that species of animal. Again, an invariant relation may be found to connect two or more processes and to constitute what we generally call the relation of cause and effect, or, apart from temporal sequence, an invariant relation in the form of a mathematical equation may be found to connect, for example, the volume and pressure of gases under given conditions. For instances of all these types of order science constantly searches, but it searches also

[3] Despite great advances in our knowledge the sources are still so fragmentary that my remarks here are quite tentative. I may refer to Otto Neugebauer, Vorgriechische Mathematik (Leipzig, Springer, 1934), to the publication of the Moscow Papyrus and the mathematical cuneiform tablets in Abteilung A of Quellen und Studien zur Geschichte der Mathematik, to the penetrating studies in Abteilung B of that series, to the articles of T. E. Peet in The Journal of Egyptian Archaeology (see also the summary of Egyptian mathematics in the Bulletin of the John Rylands Library 15 [1931] 409-441), and to the editions of the Rhind Papyrus by Peet (1923) and by A. B. Chace, H. P. Manning, L. S. Bull, and R. C. Archibald (1927-1929).

for even more comprehensive manifestations of order in nature under which the former might be subsumed, such as a theory of universal gravitation. Science discovers these invariant relations, or laws, from the most restricted to the most comprehensive type, by reasoning about that which is observed in nature. The scientist submits his guesses, hypotheses, if you will, to the test of experiment, and discards, refines, or expands his hypotheses on the basis of his observations, ever trying to see in the particular problem a manifestation of a larger order.[4] Toward the formulation of hypotheses the scientist is aided by his knowledge of phenomena and by genius. It is this genius that enables him to see an analogy between the phenomena in question and other phenomena that have previously been dealt with successfully, or to abstract from the complexity of phenomena precisely those features which will reveal an underlying order previously not appreciated, and thus, by a change of viewpoint, to open new vistas and possibilities of conquest. Now these very elements of reason and observation, of analogy and abstraction, of hypothesis and experiment played their part in the science of the Greeks as well as they do in modern science, and on a scale by no means as restricted as certain critics of Greek science would have us believe. Finally, in ancient as well as in modern science the goal of a completely rational system embracing all nature, though never realized, is always a challenge and a guiding force.

The mutual interplay of reason and extraordinarily keen observation towards the goal of a completely deductive science based on assumptions suggested by the observations is well exemplified in the development of astronomy among the Greeks from Thales and Pythagoras to Ptolemy.[5] Not only the discoveries, inferences, and conjectures, of a substantive character, e.g. the sphericity and the size of the earth and of the heavenly bodies, the source of the moon's light, the explanation of eclipses, the obliquity of the ecliptic, and the precession of the equinoxes, but the solutions of the geometric problems involved in reducing to order the motion of the heavenly bodies, whether by systems of concentric spheres or by systems of eccentrics and epicycles, are, and will always remain, classics of scientific thought. In this connection, it should be noted as a special achievement of Greek science that the possibility of more than one choice of coördinates by which to orient the cosmos was appreciated in some quarters and led to the notion of the earth's daily rotation about its axis (Heracleides of Pontus) and of its annual revolution around the sun (Aristarchus of Samos). That certain of the assumptions in Greek astronomical works such as Aristarchus' On the Sizes and Distances of the Sun and Moon and Ptolemy's Almagest are now, as a result of superior measuring instruments, known to be erroneous, should not at all detract from the authors' achievement from the point of view of method.

Other fields which lent themselves to organization in a deductive mathematical system based on postulates suggested by experience, and in which the Greeks seem to have laid firm foundations were optics, hydrostatics, acoustics, and certain branches of mechanics. For example, Euclid and Hero[6], basing their analysis on the equality of the angles of incidence and reflection, an equality which experience indicates, deduce propositions with respect to images in mirrors of various shapes and combinations. Ptolemy studies refraction experimentally and finds that his measurements need only small correction to make them accord with his hypothesis as to the precise mathematical relation connecting the angles of incidence and refraction. In this search for a mathematical relation connecting two variables (angle of incidence and angle of refraction), even though the particular relation adopted is not the true one,[7] it is to be noted that Ptolemy is using methods which have been so widely applied since Galileo's time that many have failed to note that they were also applied long before. From postulates on the nature of fluids, again suggested by phenomena, Archimedes deduces fundamental propositions in hydrostatics, e.g. that a body immersed in a fluid loses a weight equal to that of the fluid displaced (On Floating Bodies, I. Prop. 7). That the

[4] The progressive generalization of viewpoint in science is well exemplified by the development, beginning with Greek notions, on a limited scale, of the relativity of motion and rest, toward the notion of generalized coördinates in modern physics. See S. Hessen, Die Entwicklung der Physik Galileis und ihr Verhältnis zum physikalischen System von Aristoteles, Logos 18 (1929) 339-361.

[5] See the summary of Greek astronomy to Aristarchus in Part I of T. L. Heath, Aristarchus of Samos (Oxford, 1913), and the more complete account in the first two volumes of P. Duhem, Le Système du Monde (Paris, Hermann, 1913-1914).

[6] Euclid, Catoptrics, Proposition 1; Hero, Catoptrics 4 (the treatise, formerly ascribed to Ptolemy, is cited from the Latin translation which is alone extant: see Hero Alexandrinus, Opera 2.324 [Leipzig, Teubner, 1900]).

[7] See the edition by G. Govi of Eugenio's (twelfth century) Latin translation of an Arabic version of Ptolemy's Optics, Introduction XXIV-XXVIII, 144.19 to end of 150 (Turin, 1885).

results in such treatises are put in deductive form should not obscure the fact that the *discovery* of the propositions may have been quite empirical, and that in any case the adequacy of the assumptions and of the development must constantly have been tested experimentally. In much the same way the quantitative relation, discovered, it seems, by the Pythagoreans, between the pitch of a vibrating string and its length, a relation which is at the foundation of Greek musical theory, must have been, together with its consequences, the subject of experimental investigation. Again, in theoretical mechanics, the substantial progress in statics that we find e.g. in the Mechanica attributed to Aristotle, and in the works of Archimedes, Philo of Byzantium, and Hero of Alexandria[8] presupposes wide experimental activity. Such experimental activity may have suggested and must have tested the principle of the lever and of the other machines based on that principle, and may well have suggested and tested propositions regarding centers of gravity or the composition of velocities.

I have selected these illustrations of the quantitative approach in Greek science to show the inadequacy of the view that would distinguish the Greek scientist from the modern scientist on the supposed ground that the former studied nature in its qualitative manifestations while the latter seeks to discover quantitative relationships connecting phenomena. As a matter of fact, however, what is manifested in phenomena are complexes of qualities, and science progresses when it is able to abstract from such complexes one quality for special consideration, and is able then to find some means of transforming the consideration of the quality in question (which may be, in itself, non-additive) to a metric basis. All science involves abstraction and there is ample evidence, in all periods of Greek science, of the type of abstraction to which I refer. Often, as in the case of dynamical theory, the deficiency or sterility of the Greek development was due to the failure of abstraction to go far enough. It was abstraction in the highest degree and a looking beyond the actual phenomena that led, in the seventeenth century, to the formulation of the principle of inertia upon which could be based a fruitful dynamical theory and, as a special case thereof, a sound development in statics.

The advance of modern science has been marked by the discovery of means, of the sort I have just now indicated, which permit of the measurement of variations in qualities under investigation, devices like the thermometer, or the spectroscope, etc. The experimental use of such instruments has, in turn, made further advance in theoretic science possible. Limited though the Greeks were in the means at their disposal for various types of scientific investigation, the striving of their best representatives was basically toward the same goal as that toward which modern science strives, and was prosecuted in the same spirit and with the same basic methodology.[9] Yet in considering the contribution of the Greeks it is better to fix attention on *their* advance over their predecessors than on *our* advance over the Greeks. At all events one should be very critical of the type of general statement frequently made to the effect that the shortcomings of Greek science were due to an aptitude for the deductive as opposed to the inductive, or the static and the geometric as opposed to the dynamic and the kinetic,[10] or the qualitative as opposed to the quantitative, or the theoretic as opposed to the practical.

I should like now briefly to indicate some examples of observation, analogy, classification, and experiment in fields other than those to which allusion has already been made. The remarkably clear clinical descriptions of the course of various diseases in the Hippocratic Corpus (Epidemiae 1 and 3), the descriptions of the structure, physiology, generative processes, embryological development, and habits of hundreds of species in Aristotle's zoological works,[11] the minute descriptions of organs and tissues and their functions by Galen[12] on the basis of careful dissection,

[8] E.g. Archimedes, On Plane Equilibriums; Hero of Alexandria, Mechanica; Philo of Byzantium, Mechanica 4 (= Belopoiika). 20-21 (where reference is made to a treatment of the theory of the lever in a no longer extant portion of the work).

[9] Of the numerous passages setting forth, in the abstract, the aims, ideals, and methods of science, good examples are to be found in W. A. Heidel, The Heroic Age of Science, *passim* (The Carnegie Institution of Washington, 1933). The detractors of Greek science have held that in practice the Greeks did not live up to these ideals.

[10] For such a view see F. M. Cornford, The Laws of Motion in Ancient Thought, 20-28 (Cambridge, 1931), and H. Dingler, Das Experiment, 210-252 (Munich, Reinhardt, 1928). The evidence, I believe, shows the view to be entirely too broad.

[11] Charles Singer in his essay, Greek Biology and its Relation to the Rise of Modern Biology, in Studies in the History and Method of Science 2.1-100 (Oxford, 1921) takes up some of Aristotle's most penetrating biological descriptions and shows how certain facts pointed out by Aristotle have waited until comparatively modern times for rediscovery.

[12] Particularly in his De Anatomicis Administrationibus and De Usu Partium. The important anatomical work of Erasistratus and Herophilus in the third century B.C. is often referred to in Galen. On the question of the extent of dissection and vivisection among the Greeks see L. Edelstein, Die Geschichte der Sektion in der Antike, Quellen und

and Theophrastus' description of types of seed germination (Historia Plantarum 8.2) constitute some of the most important material, from the point of view both of substance and method, which Greek science has left us.

Of analogical reasoning on the basis of similarities e.g. between lower and higher animals, between plants and animals, between the organic and the inorganic, many examples might be cited, particularly from certain treatises of the Hippocratic Corpus.[13] I may also refer to the famous fragment of Empedocles (in Aristotle, De Respiratione 13) in which the poet seeks to explain respiration on the basis of the action of the clepsydra.

As an outstanding example of classification I may cite the classification which is implicit in Aristotle's zoological works.[14] It is a great achievement of trained observation that on the basis of the recording of something more than five hundred species—a half million species of insects, alone, are said to be known today—Aristotle was able to classify the animal kingdom along lines which in many respects are still regarded as valid.

I have in what preceded referred at many points to experiments and the experimental method. I should like to refer to a few additional examples. The phenomena of suction were studied at a very early date in connection with the question as to the corporeality of air and the existence of a void. From elementary experiments with siphon and clepsydra began the development which culminates in the ingenious experiments and devices described by Philo of Byzantium and Hero of Alexandria.[15] The experiments described in the Hippocratic Corpus,[16] the interesting quantitative experiment of Erasistratus in which the loss of weight suffered through perspiration and respiration is measured,[17] Galen's physiological experiments to determine e.g. the mechanism of respiration and pulsation, the functioning of the kidneys, the connections and mechanism of brain and nervous system,[18] are some of the many that come to mind in this connection.

Now it is quite true that, in proportion to the whole of Greek scientific literature, the part devoted to the actual description of method, observations, and conclusions in organized experimental work is small. But it is to be remembered that the publication of the results of experimental research as such, which is so important a factor in scientific progress today and which bulks large in current scientific literature, was much more restricted in antiquity. Furthermore, ancient sources generally inform us of results rather than of experimental technique and procedure.[19] That is one reason why the *literary record* of the experimental activity of the past is no safe guide to the actual extent of that activity. Again, technological advances bespeak a constant activity in experimentation, an activity which for various reasons did not find its way into the literary record. In this we may see a difference between the modes of disseminating scientific information in ancient and in modern times, but not a generic difference between ancient and modern science, as such.

Studien zur Geschichte der Naturwissenschaften und der Medizin 3 (1932) 100-156, as well as the pertinent material in the works cited in note 1, above.

[13] E.g. in De Semine, De Natura Pueri, De Morbis 4. On analogy, particularly in the Hippocratic Corpus, see O. Regenbogen, Eine Forschungsmethode antiker Naturwissenschaft, Quellen und Studien zur Geschichte der Mathematik, Abteilung B, 1 (1931) 131-182.

[14] See pages 15-20 of the paper cited in note 11, above. Note, in particular, the inclusion of Cetacea among the viviparous species (Historia Animalium 6.12).

[15] Hero of Alexandria, Pneumatica; Philo of Byzantium, Pneumatica (an Arabic version of the lost Greek text and, for certain parts, a medieval Latin version of an Arabic version are available). The atomistic approach of these authors and of various medical writers suggests the influence of Straton of Lampsacus, who combined certain features of atomism with Peripateticism.

[16] On experiment in the Hippocratic Corpus see T. Beck, Das wissenschaftliche Experiment in der Hippokratischen Büchersammlung, Verhandlung der 49 Versammlung Deutschen Philologen und Schulmänner, 197-201 (Leipzig, Teubner, 1908); A. Bier, Hippokratische Studien, Quellen und Studien zur Geschichte der Naturwissenschaften und der Medizin 3 (1932), 51-78, and the articles of G. Senn there (71, note 5) cited. Bier erroneously holds (73) that the Corpus is entirely philosophical rather than scientific, disregarding its diverse composition which exhibits many different degrees of empiricism.

[17] A bird is kept without food; the difference between the original weight of the bird and its weight at a subsequent time together with that of all visible excreted matter will measure the loss through other channels (Anonymus Londiniensis 33.45-51 [Diels]). Despite its crudeness, there is implicit in this experiment a notion of conservation of mass. At the beginning of the seventeenth century Sanctorius performs similar experiments on human beings and initiates the modern study of metabolism.

[18] For examples of experiment in Galen see pages 884-886 of the work of Brunet and Mieli cited in note 1, above. Of particular interest are experiments involving the vivisection of animals, e.g. those experiments in which the spinal cord is cut into at various levels, and the particular type of paralysis resulting from severance at a particular level is noted.

[19] See Charles Singer, Greek Science and Modern Science—A Comparison and a Contrast, 16-20 (London, University of London Press, 1920).

The fact that those Greek scientists of the early period of whom literary records are preserved were also philosophers and the fact that over a long period of time the most influential figure in Greek science was Aristotle[20] have combined at times to give the impression that Greek science was philosophical rather than scientific. That one and the same person may have devoted thought to both scientific and philosophic questions should not, however, prevent us from appraising his contribution in each field, any more than the presence of superstitious elements in an ancient scientist should be permitted to obscure his really scientific work. Lynn Thorndike in the first volume of his well-known work, A History of Magic and Experimental Science, emphasizes magical and mystical features in certain Greek and Roman scientists to the neglect of the scientific element in their work. But the distinction in aim and spirit between magic and science cannot be too strongly emphasized. It should be remembered, furthermore, that science in its quest for more and more comprehensive viewpoints, a quest to which I have made reference, often finds itself at the borders of philosophy. And the borders are ill-defined precisely because it cannot always be foretold what will prove capable of verification or falsification and what will not. In any case science can never be completely divorced from philosophy whether the latter serves merely to interpret the propositions of science or to criticize its reasoning and abstractions, or to formulate theories of knowledge and reality upon which a system of science must be based.

Indeed, great as is the achievement of Greek science in its second great period, the Hellenistic, with its specialists in mathematics, physics, astronomy, medicine, biology, and geodesy, it may reasonably be held that it was precisely in the union of science and philosophy in the earlier period that Greece made a more significant contribution to the future. It is from this period that we have our first record of sustained and penetrating thought on questions that in one form or another have continued to engage men's minds. I have already referred to some of these basic questions. It is of particular interest to consider this matter at present when the relation between science and philosophy is more intimate than it has been for a long period, a rapprochement necessitated by the fundamental questions raised in connection with relativity theory, new viewpoints in atomic physics, and the basic principles of biological science.

I need but mention at this time, in connection with Greek scientific achievement, the notion of the basic unity of nature, the idea of element in the theory of matter, the elaboration of the atomic hypothesis, the penetrating attempts to understand the nature of chemical change, the abstraction of the notion of force, the steps toward principles of conservation and least action, the concept of organism in biology, the beginnings of a theory of evolution.[21] Thought on basic scientific questions such as these leads naturally to thought on more general philosophic questions culminating in the problems of universals, of causality, of God.

The achievement, then, of the Greek mind at the various levels of scientific activity is a rich achievement both in substance, and in what is even more important in the history of civilization, in spirit and method. It is unnecessary to enter into the question as to whether the achieve-

[20] The great importance of Aristotle should not be permitted to obscure contrary currents such as the development of atomistic viewpoints in mechanics and medicine (see note 15, above) and criticism of Aristotelian dynamical theory, e.g. in the school represented in later times by Philoponus. This is, of course, apart from a general tendency toward empiricism and scepticism, a tendency which was manifested in greater or lesser degree in various periods of Greek science and philosophy as it has been in modern times. Such tendencies are usually corrective reactions against an excessive tendency in the other direction. In fact Aristotle himself represents, in a sense, a reaction toward empiricism from the tendencies of Platonic science.

[21] With respect to all these items source material abounds. I have also found the works of Émile Meyerson, especially his Identité et Réalité, very valuable in tracing the development of scientific ideas like atomism, inertia, conservation of matter, etc., from ancient to modern times.

In connection with the theory of chemical change the development of two schools, that which goes back to Aristotle's De Generatione et Corruptione and that which goes back to the ancient atomists is traced by P. Duhem, Le Mixte et la Combinaison Chimique (Paris, Naud, 1902). Note also the literature referred to in Chapter 7 of the work of Brunet and Mieli cited in note 1, above.

With respect to the principle of conservation of weight see note 17, above, and compare Lucian, Demonax 39. In connection with the conservation of effort and the principle of least action see 156.6 of the work cited in note 7, above.

Very instructive are analogies between ancient and modern theories of elements, e.g. in the matter of differentiation by shape (compare ancient atomic theories as well as the rôle played in antiquity by the five regular polyhedra with modern atomic models) and of transmutation (compare ancient theories with modern results in connection with radioactivity and the bombardment of atomic nuclei).

The modern controversy as to determinism and indeterminism in physics (a controversy now raised in connection with quantum theory) may be compared to a similar controversy in ancient atomism (note the function of the Epicurean *clinamen*).

ment of the Greeks in non-scientific activities, in art and literature, is more significant. It will suffice here to point out that certain qualities of the Greek mind, its innate curiosity, its aesthetic bent, love of order, rationalism, and so forth, reveal themselves in both spheres of activity. But since it is the scientific achievement of the Greeks that has been more often forgotten, it is well to call special attention to it now. Classical students have in the past been criticized for not paying sufficient attention to this achievement. But scientists were at least equally to blame because for so long they taught science as if it began in the sixteenth century or even in the nineteenth century. In recent years, however, both among classicists and among scientists there has been not only a somewhat more sympathetic appreciation of Greek science but a growing feeling that the scientific spirit is in no sense opposed to the classical spirit, and in no sense opposed to the truly humanistic spirit. Be that as it may, the classicist ought to be able, it seems to me, to appreciate Greek science without losing any of his love for Greek art and literature, and the scientist ought to be able to do the same without losing any of his profound admiration for the modern kingdom of science.

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REVIEWS

The Transition from the Ancient to the Medieval World. By R. F. Arragon; pp. vi, 134. New York: Holt, 1936. (Berkshire Studies in European History.) $1.00

This comprehensive and well-written survey (designed as a week's collateral reading) will prove useful to two classes of reader: the undergraduate student will come from it with a clear idea of the main lines of political, economic, and cultural development during the late Empire, and those who are engaged in teaching general courses in Roman or Medieval History will gain here a bird's eye view of the period and will particularly welcome the critical summary of the special theories which have been put forward to account for the Decline and Fall. The title of the book is significant of the author's intention to regard the centuries falling between the Antonines and Theodoric not primarily as a decline from the standards of civilization set by the preceding two and a half centuries, but as an organic historical process having its own significance by virtue of its continuity with earlier and later processes; and it may be said at once that Professor Arragon has in the main performed his difficult task of condensation and appraisal successfully.

Constitutional and political changes are treated with economy of statement and good judgment. The sections on government intervention and eventual decentralization, occupational and financial obligations to the State, and the implications of universal citizenship and a universally operative legal code may be singled out for their effectiveness. Considerations of space apparently prevented the inclusion of a section or two on the qualities of Byzantine culture and its connections with the Persian and Islamic cultures; a few pages added at this point would have rounded out the account and served to correct the widespread notion that Byzantine history is simply the tail end of Roman decadence.[1]

In the second chapter, which outlines economic and social change, the present survey renders its greatest service. Here a variety of controversial issues and matters of basic importance are ably condensed and handled with critical tact. Professor Arragon convincingly shows how bureaucratic policy injured commerce and agriculture by draining off 'the wealth of the productive classes at the same time that it strangled their economic activity' (43); how a policy of peace, manumission, and a low servile birth-rate reduced greatly the supply of skilled slave labor before the third century and undermined the prosperity of agriculture and capitalistic manufacturing; why international trade declined and how localization of industry, commerce, and agriculture paralleled decentralization of government; how the villa system and the ascendancy of agriculture over industry and commerce spelled the ruin of classical urban civilization and foreshadowed the later social conditions of feudalism and serfdom.

The collapse of ancient society has seemed to the modern world so complete that scholars have gone behind economic and sociological causes and have proposed various climatic and biological theories to account for its all-inclusiveness: soil exhaustion, extended periods of drought or cumulative diminution of rainfall, racial degeneration, a falling birth-rate especially among the upper classes, an exhaustion of society analogous to the aging of an organism.[2] These proposals,

[1] The proper distribution of emphasis between West and East, which is an exacting task for any historian of this period, is finely preserved in the excellent volume of H. St. L. B. Moss, The Birth of the Middle Ages (Oxford: Clarendon Press, 1935) 395-814.

[2] Arragon does not reckon with the bubonic plagues, which, frightful though they were, are given undue emphasis by Hans Zinsser in Rats, Lice and History.

which at best must remain partial explanations and at their worst are unscientific, are competently examined by Professor Arragon and every fair-minded reader with no specialist's ax to grind will be grateful for his brilliant presentation of the intricate problems involved and will feel inclined to rely upon the impartiality of his judgment. Two general objections, he finds, may be urged against the non-sociological theories: first, every theory of this class is either scientifically provable but remains as yet unproved because of deductive reasoning or the inconclusiveness of the data, or it is unscientific and rests on prejudice or analogy (such are the theory of degeneracy through racial intermixture and the life-cycle theory); and secondly, all theories of this kind tend to exonerate man at the expense of nature. Production declined because, 'so far as we certainly know, the control and use of natural resources changed rather than the resources themselves, the organization of society rather than the physical environment' (71). Miscegenation did not weaken racial stock; it did weaken the ligaments of society by diluting cultural traditions. The all-inclusive formula of the birth, maturity, and decline of civilizations, which has been revived of late by the romantic pessimist Oswald Spengler, is of all naturalistic theories the least susceptible of scientific proof. If we may figuratively speak of loss of vitality on the part of the Roman world, we must remember that we are not stating a biological fact but describing a sociological process, 'a weakening of the distinctive social ties of antiquity and of the incentives, aspirations and ideals of classical civilization' (81).

The concluding sections of the book deal topically with the cultural residua of the Empire. Younger students are sure to find much illumination in the sections on the Use of Allegory, The Failure of Classical Ethics, and the Rise of Faith. An account of the Christian view of life ends the survey, and the story of the interaction of Church and pagan society is properly reserved for a companion volume of The Berkshire Studies.[3]

GEORGE K. STRODACH

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Daughters of Atreus. By Robert Turney; pp. 127. New York: Knopf, 1936. $2.00

This reworking of the familiar Agamemnon-Choephoroe tale is a first play whose author seems likewise to be conversant with the remainder of Greek tragedy and with Homer. By reworking I do not mean such perfumed efforts as those of Spitteler to naturalize Greek myth in a modern fairyland of poetry and philosophy, nor again the psychoanalytic and febrile adaptations of von Hofmannsthal. Mr. Turney makes with the resources of modern dramatic art an honest, often a fortunate attempt to lure onto our stage the spirit of the Mycenean era.

True, in the working out of extraneous characters like Fria, Vortigern, Cheops, and Aesculapios (sic), he often gives information astoundingly new to a scholar. Occasionally also there pervades his scene a rationalizing temper more fitting the fifth than the twelfth century B.C., a totally modern conception too of Greek restraint, moderation, and what not that jars. This last offends one almost as much as the Greek-life-was-one-long-revel tune of neo-pagans. In America it is of course only the Puritan inheritance that descends through our theological approach to the Classics, plus the playing field of Eton and Rugby-cum-Renaissance reverence. I don't think the Myceneans were so civilized as Homer, let alone Mr. Turney, makes them, certainly not so restrained as a professor of Greek lecturing on Sophocles to a ladies' seminary.

The play, though, embodies again and again the very spirit of pure poetry. It is well-written, too well in fact. From the closet its long speeches soar. On the stage, during a brief life (October 14-24) recently in New York, it limped even in the expert hands of Eleonora Mendelssohn (Reinhardt's leading lady), Maria Ouspenskaya (veteran of the Moscow Art Theatre), and others, when they carried it through after a magnificent first act which included the slaughter of Iphigenia. The stage-director evidently thought Mr. Turney was better than Shakespeare, who regularly in wise hands gets at least a little dose of condenser and play-doctor. Mr. Turney is good, but not so good as all that.

F. A. SPENCER

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Roman Gaul: The Objects of Trade. By Louis C. West; pp. xi, 191. Oxford: Basil Blackwell, 1935. 7s 6d

West continues his series on the objects of trade in the Roman provinces under the Empire with a third book, devoted to Gaul. One chapter is allotted to each group of commodities and to certain miscellaneous items such as waterways and foreigners. Each chapter ends with a table listing the individual objects, their place of origin and place where found. What little value the book possesses lies in these tables, for the brief commentaries consist of a series of chatty remarks showing no historical insight, antiquar-

[3] E. R. Goodenough, The Church in the Roman Empire. New York: Holt, 1931.

ian, uncritical and not always consistent. Two sentences on p. 162 are typical: 'There is little in the inscriptions of the imperial period to sustain the commercial importance of the Greeks in Gaul. It is interesting to note, however, that the father of Ausonius spoke Greek more readily than Latin.' West's conception of the Roman Empire, and specifically of the economic position of the provinces is hardly one upon which to build a realistic discussion of Gallic trade. He says (171): 'It must be assumed that in very large part the exports from Gaul were paid for by imports of other goods, for ancient trade could no more be indefinitely maintained by an exchange of goods for money than can international commerce of to-day.' This failure to understand the nature of Roman exploitation illustrates West's whole approach.

This book would still be a real contribution if the collection of materials were exhaustive. Unfortunately, that is not the case. Thus, Table IX (Mines and Minerals) lists seven gold-producing regions in Gaul. A hasty examination of A. Grenier, Manuel d'archéologie gallo-romaine (vol. 2, Paris 1934) reveals three times as many, and the same dearth of material can be shown for nearly every other item. Finally, we must protest against the lack of a map and index and against the preposterous system of abbreviations whereby the various volumes of CIL are cited W, AC, KU etc., the Revue des études anciennes BZ, Apuleius EH, and so on.

MOSES I. FINKELSTEIN
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Aristotle: Fundamentals of the History of His Development. By Werner Jaeger, tr. by Richard Robinson; pp. 410. Oxford: Clarendon Press, 1934. $6.00

Classical scholars as well as students of philosophy will welcome the translation into English of this scholarly work on Aristotle's philosophy. For practically the first time, we have in the case of Aristotle something that has so frequently been done for Plato, namely a comprehensive treatment of his thought as an historical evolution with definite stages of development. As against the older tradition, which minimized the importance of Aristotle's dialogues and tended to regard his treatises as 'all of a piece' and composed entirely during the period of his teaching at the Lyceum, Professor Jaeger shows with great plausibility that Aristotle began writing at an early period, that his philosophy exemplifies a steady change from pure Platonism, and that many difficulties in interpreting the extant treatises are due to the fact that he incorporated into these lecture-notes material drawn from his earlier published works.

The thesis assumes three main stages in the development of Aristotle's philosophy. The first is almost purely Platonic and is assigned to Aristotle as a student at the Academy before 347 B.C. The second, the period of his independent metaphysical development, is assigned to the time of his teaching in Asia Minor and his tutorship of Alexander, 347-335 B.C. The last, after the founding of the Lyceum at Athens, is regarded as a period of almost exclusive interest in scientific research. Emphasis is laid on the importance of Aristotle's dialogues, and the 'exoteric discussions' frequently referred to in the treatises and in later antiquity are consistently interpreted as designating these published works, belonging to the first and second periods. Jaeger has done excellent work in assembling the extant references to these earlier works, and in giving us an excellent idea of the Eudemus and the Protrepticus (purely Platonic and belonging to the first period), and of the dialogue On Philosophy (regarded as Aristotle's definite break with Platonism and written during the middle period).

Professor Jaeger also submits the Metaphysics, the Ethics, the Politics, and the Physics to a careful examination, and comes to the conclusion that each contains an earlier, more Platonic, viewpoint, which is later combined with a more developed and pure Aristotelianism expressed in other books of the same treatises. Thus, in the Metaphysics, there are two distinct definitions of the science, the one defining the subject as the science of eternal and supersensible being, the other as the science of being as such. The first definition is obviously closer to Platonism, the latter is more similar to what we ordinarily regard as pure Aristotelianism. Using this criterion along with others (e.g., the use or non-use of the pronoun 'we' in referring to the Platonists), Professor Jaeger make a good case for his assignment of the various books of our present Metaphysics to different stages in Aristotle's own intellectual growth. The same thing is done for the other three works. Particularly interesting is the analysis of the Eudemian Ethics as representing a midway stage between Platonism and the Nicomachean Ethics. The thesis of a changing and growing Aristotle is justified, not only from its inherent probability and from the frequent citations of the extant fragments of the dialogues, but also from its applicability to the solution of problems and inconsistencies in the above treatises.

The last period of the great philosopher is regarded as given over to his teaching at the

Lyceum, and to the organization of historical and scientific research, with the published works of his middle period forming the background for his lecture-notes (our present treatises), while his own interest became increasingly scientific rather than metaphysical.

Professor Jaeger has given a most scholarly and interesting interpretation of the evolution of Aristotle's thought, and one which seems to fit the facts and to solve many difficulties. The work is of definite value, too, in giving us a living portrait of Aristotle the man, in his human relationships, a side of the great philosopher too often neglected. The book contains a great amount of historical information as well as a comprehensive view of Aristotle's works. It is a pity that the philosopher's logical works are not dealt with so thoroughly as are the others. They are mentioned only incidentally in a section of the last chapter.

Professor Robinson has made a clear and readable translation of the book, in which awkward 'Germanicisms' seldom occur. Greek quotations have usually been translated into English for the benefit of the reader who is not a classical scholar. Sometimes the Greek is omitted entirely and only the English translation is given. Occasionally this is somewhat inconvenient, particularly where there is a possibility of other interpretations or translations than those quoted. These are, however, minor criticisms, and do not alter the fact that we have here an excellent translation of a most significant work.

B. C. HOLTZCLAW

University of Richmond

Monuments and Men of Ancient Rome. By Grant Showerman; pp. xxvi, 344. New York: Appleton-Century, 1935. $5.00

'Nothing so brings to life the ancient authors, nothing so makes dynamic the content of their works, as viewing with them the scenes their eyes once looked upon and their feet once trod, and reading the words they wrote on the spot on which or concerning which they wrote them.' In these words, which conclude the preface of the book, Showerman states its aim.

The opening chapters tell of the city and its monuments, and of the processes by which the monuments were buried and are now being brought again to the light. I have seen no more convenient popular description of the recent archaeological developments in the city. This is by way of general background; then the great men of Rome are presented one by one, each in his special environment. We see Cicero at his villa where the Fibrenus joins the Liris, Horace in the Forum or on his farm, Hadrian moving from city to city across the Empire, and Marcus Aurelius in his camp on the Danube. The reader is brought to a clearer understanding of Vergil's poems by seeing the country-side in which the poet was brought up, the land he praised in the Georgics, and the scenes through which Aeneas moved; and from understanding the poems he comes to understand the poet himself.

One expects little that is new in a work of this sort. Showerman says nothing that has not been said before, but here as in all his books he writes with a boundless enthusiasm for his subject. At times one might wish that the enthusiasm had been kept within bounds. The account of Cicero occupies eight of the thirty-five chapters, and would satisfy the soul of the orator himself. The over one hundred and fifty illustrations, most of them from photographs by the author, are interesting and add greatly to the value (and the expense) of the volume, but they demonstrate once more that the amateur should not present his work in competition with the professional. The errors of fact are relatively few and unimportant, but unfortunately the worst of them are concentrated in the first chapter. The reader is tempted to lay down the book in disgust when on pages 3 and 4 he reads that the fall of Veii 'brought all of Etruria . . . under Roman authority'; that every part of Italy outside Latium 'had been first the subject of Rome and then her ally'; that after Sulla Italy was usually governed by propraetors or proconsuls; and that after 89 B.C. 'the granting of the full franchise in Italy increased in liberality until in Caracalla's time it became universal for free men,' the context showing clearly that the statement is to be applied to Italy only.

RUSSEL M. GEER

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FROM THE EDITOR'S MAIL

Some of the letters which are addressed to the Editor but are really directed at the readers of CW. The limited space available forbids publication of all of them and even necessitates some abridgement of those presented. The views expressed are, of course, not necessarily those of the Editor.

Revive the Summer Session

The Summer Sessions of the American Academy in Rome were ably directed by the late Professor Grant Showerman for ten years. There are many who believe that they should be revived. Certainly they afforded an invaluable opportunity to many teachers who were quite unable to take time from their regular duties to study abroad. A staff of three or four could

organize and direct a six-weeks' session, and could offer, in addition to a general cultural course, supervision of specialized study in a number of fields, one of which would be open to each student. The tuition fee used to be only fifty dollars. For such a session as I describe a fee of one hundred dollars would be quite modest. I feel confident that enough students would enroll to justify the venture. . . .

JOHN FLAGG GUMMERE
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Philadelphia, Pa.

Notes to W. K. Prentice

What a glorious opportunity was missed in Professor Prentice's address on 'The Study of the Classics'! The first part of it is splendid—its trenchant criticism of 'Latin as she is taught' (all too commonly), much needed. We must indeed 'stop teaching our pupils to understand Latin by translating it into English,'—or rather stop trying to. For how can one, properly speaking, 'translate', i.e. 'carry across' the meaning of a Latin sentence or paragraph unless one has first got that meaning?

But just when there should come a clarion call to a vigorous reform in our methods and a determined effort really to teach our pupils to read Latin, or Greek, I read with growing amazement in the second part of the address proposals that amount to a complete surrender of the case for the classics. For what more can the worst enemy of classical studies say than that it is not 'even desirable for many to spend much time, even for a few years, in learning the Latin or the Greek language for the sake of reading the literature in these languages?' . . . Professor Prentice ends by suggesting that 'without even reading the classical literature in class in any way, if we choose to abandon reading it in our classes, we can teach a great deal that would be most valuable . . . about the classical civilizations.' Facilis descensus Averni!

Well, I for one do not choose to run the classical race without reading the classics in the original. As Professor Prentice himself points out in the earlier part of his article, learning to read foreign languages, Latin included, though difficult, is not impossible; and I venture to assert that it is worth all that it costs in time and effort. Only we must not set up an impossible standard. The special circumstances and conditions that led to that kind of virtuosity in the use of Latin which Professor Prentice found in his German seminar at Halle are, no doubt, 'gone with the wind.' But it by no means follows that we should abandon any attempt to read the classics in the original and so deprive our students of one of the richest and most rewarding linguistic experiences they could possibly have.

The thing we ought to abandon is the undue, and indeed oftentimes exclusive, emphasis we have been putting on translation into English. If we substitute for this much reading aloud of the Latin with proper attention to the natural grouping of the words, without ever transposing into the English order (which means disrupting the Latin sentence), we shall find that we can gradually develop in our students the power to take in thoughts in the Latin order. This is practically *thinking* in Latin.

EDITH FRANCES CLAFLIN
Columbia University

Acu rem tetigit Professor Prentice although I do not find myself wholly in accord with his proposal to teach through translations. Agreed, if that be second choice; agreed, if the teaching of Latin itself be of such quality that only thus a closer acquaintance with ancient literature is gained; agreed, if the subject matter chosen for courses in the ancient languages be less interesting, less revealing, less instructive than that offered through the medium of translation, but not otherwise.

I believe, however, that courses in both Latin and Greek can be framed to attain this object. . . . Are there not passages galore in Livy, instructive and interesting? . . . What of Tacitus' Agricola? Why not a touch of Plautus for a breath of everyday Latin? Vergil in translation is a travesty, but read aloud! Then let us take a bit here and there of Quintilian. Then there is not a little in mediaeval Latin. But why continue? The list is too long. Instead of naming rules, calling subjunctives incomprehensible names, let us try by applying some of Cicero's simpler rules of rhetoric to our passages to inculcate a feeling for style and for rhythm. . . .

With Professor Prentice's requirements for teachers, I am in thorough accord. . . . Certainly no teacher who cannot write, who cannot read aloud, and, I believe, who cannot speak Latin, can fully bring out the sonorous beauties of that language, cannot thrill his pupils. . . . Before we give up in despair, let us try it as a living language and present it with material apposite to our day and to our problems. This can be done.

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Correction

In my article on Charles Knapp, CW 30 (1936) 14, I stated that at the Princeton Meeting the Classical League was formed and the Classical Investigation started. This is inaccurate, insofar as the official steps initiating both belong to later meetings, in connection with the National Educational Association, in 1919 and 1920.

This much is true, however, that the ideas, from which the official procedure was born, were first brought forward and discussed at Princeton. I should be sorry to give the impression that I wanted to deprive those of credit to whom such credit is due.

ERNST RIESS
White Plains, N. Y.

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